Chapter Two - Population Ecology

- **Population** is a group of organisms belonging to the same species occupying a particular space at a particular time.
- Individual members of a population are interbreeding and live in a particular place, in the same time and interact to one another as a society.
- ***To be considered as a population it should fulfill the following points***:
  - ✓ members must belong to the same kind of species
  - ✓ all the members must occupy the same place
  - ✓ members must live in the same time and
  - ✓ members must interact with one another
- Population is the basic unit of a community
- **Population** ecology, hence, deals with the distribution and abundance of a population and the factors governing them

Importance of Socialization?

The degree of socialization or interaction in of a population ranges from the most solitary animals like humming bird to the most complex interaction in social insects such as termites and honeybees.

- ***Collective defense*** **-** group fighting or confusing predators
- ***Improve foraging efficiency*** **-** mutual vigilance
- ***Social facilitation*** **-** learn some of the behaviors by imitating from the action of the members of the flock
- ***Information transfer-***"waggle dance" in worker bees
- ***To Overwhelm larger prey*** **-** soldier ant can hunt large lizards
- ***Modify*** *the* ***environment*** – thermoregulation

Characteristics of a Population

- A population, as a group, has unique characteristics, which can be statistical measured, and cannot be applied to individual organisms. The three basic group characteristics of a population are:
  - density,
  - primary population parameters, and Secondary population parameters

Density

- It is defined as the number of individuals of a population per unit area (volume)
- Density varies with time and space
- Individuals in natural populations are affected by their density

→ If the population density is high, resources are shared unequally

→ if the density is very low, it reduces the chance of performing behavioral activities essential to the welfare of the population.

Methods of Measuring Population Density

- There are two major ways of measuring a population density. These are ***absolute density and relative density***

❖ **Absolute Density (actual count)** is the actual number of individuals of a population in a known area or volume (per m^2 or hectare, etc) in its habitat

- There are two ways of determining the absolute density of a population. These are ***total count*** and ***sampling method.***

Total counting e.g. Census

- *Involves encountering (counting) each and every individual of a population in a* given area or volume

→ Have higher precision as compared to the sampling method

→ Could be aided by aerial photography and sophisticated radio and infrared technologies.

→ may demand much resources and time. As a result, ecologists are inclined to using the sampling methods

Methods of Measuring Population Density

Sampling

Is a process of selecting representative part of a population, and drawing conclusions about the larger population using the information gained.

- Samples are individuals that fully represent the larger population.
- Sampling involves counting a small proportion of a population and estimating the total.

❑ The two major ways of sampling employed in ecological studies are ***quadrat method and trapping techniques.***

A. Quadrat Technique is a sampling area of any shape (usually rectangular or triangular frames) with limited area, made either from wood, metal, strings or any materials.

- **The quadrat** is simply a delineation used to demarcate the sampling area
- **A simple square quadrat** could be constructed from four sticks that have equal length. It is used to sample less or non-mobile organisms such as plants, amphibians and the like

Method of Sampling in Determining Population Density

- **Transects** are also long and narrow quadrats used for the same purpose especially when sampling of larger plants and animals in a landscape.
- Transects could be also made using **flags or natural or man-made reference points such as roads**, riverbanks, simply to delineate the boundaries of the sampling area
- ***The quadrat technique involves***
  - → the selection of the appropriate sampling technique (such as random, stratified or cluster sampling) depending on the study area,
  - → Counting all the individuals in each quadrat and
  - → extrapolating the average to the whole area, from the number of samples taken at each quadrat.
- ***The reliability of this technique, however, depends on:***
  - determining the exact population of each quadrat;
  - knowing the area of each quadrat; and
  - representativeness of the quadrats to the whole area

Method of Sampling in Determining Population Density

Quadrat sampling follows the following procedure:

→ Selection of appropriate sampling strategy to survey the study area. You can prefer ***random, systematic or stratified sampling*** depending on the nature of the environment.

- Random sampling is used if individuals are distributed randomly in space, and there is equal probability of finding any individual at any place.

→ Decide the quadrat size. There are different techniques of determining the quadrat size. One of the famous techniques is the ***Nested Plot Analysis***. We usually use 20m by 20m for natural forestlands, 4m by 4m for shrub lands, 2m by 2m for herb lands and 1m by 1m or less for managed pasturelands.

→ Determine the sampling size (number of samples) you should take

→ Estimate the number of individuals in each quadrat.

→Take the average of each quadrat and extrapolate to the larger study area.

Method of Sampling in Determining Population Density

B. Capture-Recapture Technique

- This technique is important to determine the population density of highly mobile animals as it gives an estimate of birth and death rates in addition to density estimate of the studied population.
- The technique involves the following procedures:
  - **Capturing**
  - ***Marking***
  - ***Releasing:*** *The animal needs to be released and given time fully to mix with the larger* population
  - **Recapturing**: After a considerable time, at time-2 (T2) we set the same kind of trap, on the same time and place that we used in the first catch at time-1 (T1)
  - **Extrapolation**: From this information we can estimate the density of the whole animal population in that specific area.

Capture-Recapture Technique ctd

Extrapolation can be done by Peterson's estimate or Lincoln Index

$$\text{Total population size (P)} = \frac{\text{Animals captured and released in the First catch (T1)} \times \text{Total animals captured in the Second catch (T2)}}{\text{Marked Animals captured in the second Catch (T2)}}$$

Drawbacks of Petersons estimate

- It assumes no mortality of marked individuals
- It assumes marks are not lost or overlooked.
- It assumes the probability of finding marked and unmarked individuals is equal

Relative Density

- **Relative Density** is the measure of the density of organisms in area **x** when compared to area **y** of similar size
- It is a technique of measuring population density from some information that has a known relation with the population
- It provides an index of abundance, which is more or less accurate and use for comparison purpose
- However, it is not as reliable as the absolute density, and it needs accurate information about the area and the organism

- **Some of the indices of relative density include the following:**
  - ***Catch Per Unit Effort****: measures the population density of an area based on the* no of individuals caught per day per a trap
  - ***Number of Fecal Pellets:*** *measure the number of fecal* droppings (i.e. dung) in an area, and the average rate of defecation.
  - ***Number of Artifacts****: looking* into the **trace evidences** that indicate the number of the population. E.g, number of footprints, degree of vegetation damage by mammals, number of bird nests, and number of pupa cases for insects
  - ***Vocalization Frequency****: It is the number of calls heard per a given time. If there is a known* index about the number of calls that a given animal could call per a given time, we can estimate the relative density of the animal in that area

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- ***Cover*** – *This is usually used to estimate the density of plants by considering the percentage of* the ground surface covered by the plant. The cover could be measured either from the *crown* or from the *base of the plant. This is used indirectly to* measure the density of a plant, especially herbs (e.g., grasses) that are difficult to count.
- ***Feeding Capacity*** – *This measures the density of herbivores from the information we have on* the degree of defoliation (leaf-cut) or amount of bite taken from the available vegetation.

Density Dependent (Primary) Population parameters

- Includes those characteristics of a population that are density dependent,
  - i.e., their magnitude directly affect the density of a certain population.
- It includes birth rate (natality), death rates (mortality), immigration and emigration.

Birth Rate (Natality)

- is the number of new individuals added to the population by birth
- largely affected by the rate of ***fertility and fecundity***
- ***Fecundity*** *indicates* the physiological capability of organisms for breeding, while ***Fertility*** *is* the number of offsprings produced during a period of time by the population.
- It is inversely related to the amount of parental care given to the young.

  e.g. fertility rate in Ethiopia is 5, while that of western nations is less than 2 per women.

- This is affected by a number of socioeconomic lives of the society.
- However, in its ecological sense, a woman can provide a child every year, to provide more than 30 children within her reproductive period (15-45). This is its fecundity.
- There are two ways of understanding fecundity:
  - ***Potential fecundity:*** *This is the potential number of offspring that a population could provide* per a given time under an ideal condition.

    For example. A woman in childbearing (reproductive) age may conceive every 10 to 11 months.
  - ***Realized fecundity:*** *This is the number of offspring that a population can provide per a given* time under actual or normal condition.

    For example, a woman in childbearing age may give only one birth per 15 years.

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Death Rate (Mortality)

- It refers to the number of individuals removed out of a population through death. It decreases the density of a population. It is affected by a number of environmental factors such as, competition, predation, disease, hereditary characteristics, etc.
- The specific age of an organism it lives in a population before its death is referred to **Longevity**. There are two types of longevity:
  - ***Potential longevity-*** *It is the* ***maximum life span*** *attainable by an individual of a particular* species. The limit is set by the physiology of the organism.
  - ***Realized longevity (life expectancy)****- is the average longevity of the individuals in a population living under real* environmental conditions. For example, the European robin has an average life expectancy of 1 year in the wild and 11 years in captivity

Dispersal/Migration/

- *Dispersal is the movement of organisms outside their normal home range for different reasons* such as reproduction, survival or spread. The dispersal could be temporary or permanent in a population

❖ ***There are two ways of migration in a population***

  – ***Emigration****: it is dispersal or migration of individuals away from the population. Individuals* leaving a population are called *emigrants.*

  – ***Immigration****: it is dispersal or migration of individuals into a population. Individuals joining a* population coming from another group are called *immigrants. It increases the population size.*

- Dispersal is common in mobile animals such as mammals, birds, fish, and insects. In the case of plants, the main dispersal units are seeds or spores.

Sex Ratio

- It is the ratio of male to female individuals in a population.
- The natural tendency of male to female sex ratio is 1 to1 (1:1).
- However this may be affected by different factors and hence affects the population size.
- Sex ratio changes with age due to differences in the mortality rate of male and female individuals.
- For example, the death rate is higher for males than female in human population, as the life expectancy of male is lower than the female.

Mating System

- The type of matting between different mating types (sexes) in a population affects the population density.

- There are three basic mating systems in a population

i) Monogamy: *This is a kind of* ***one-to-one*** *marriage that demands a persistent pairing between a* male and a female

  - >90% of avian species are socially monogamous.
  - On the contrary, only 3% of mammals and up to 15% of primates are socially monogamous

ii) Polygamy: *It is a pairing between an individual with more members of the opposite sex (male* or female).

- Three types of polygamy are recognized:
  - ***Polygyny-*** *This is most common polygamous type of mating system in which one male* pair with two or more females.

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- ***Polyandry***- *It is a kind of mating type in which one female pair* with several males. It is common in honeybees, termites and a number of social insects.
- **Polygynandry:** In this kind of mating, two or more males pair with two or more females. The numbers of males and females need not be equal

iii) Promiscuity*: It is a kind of mating type where there is no order of pairing between individuals of* different sexes.

- Any male and female will mate within the social group.
- Two examples of promiscuous mating systems in primates are chimpanzees and bonobos

Density Independent (Secondary) Population Parameters

- Are not associated to the density of a given population.
- They do not necessarily affect the density of a given population, hence called ***density independent parameters.***
- Affect population size regardless of its density.
- These include **age distribution, genetic composition and spatial distribution of individuals.**

1. **Dispersion /Spacing pattern/** is the spatial pattern of individuals in a population relative to one another.

- There are three basic patterns of dispersion: Regular, Random and Clumped

i) Random distribution- *In this kind of dispersion, the position of one individual in a population* is ***unrelated*** to the positions of its neighbors. rare in nature it is evident in forest trees, and invertebrates of forest floor.

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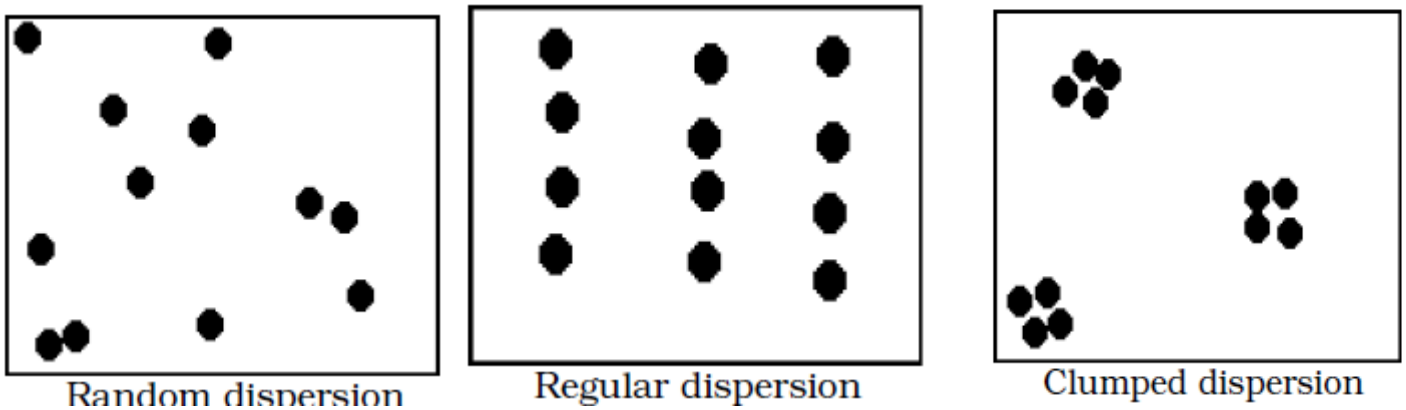
ii) Regular /Even/ distribution – *Individuals of a population are more or less* ***equidistant*** *from one* another. It is rare in nature but common in managed systems like in crop plantation or territorial animals

iii) Clumped /Aggregate/ distribution- *In this kind of dispersion, individuals of a population are* aggregated into patches.

- This could arise from :
  - socialization tendency of individuals,
  - clumber nature of resource distribution in nature or
  - the tendency of offspring to remain into close distance with their parents.



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2. Age Structure: refers to the proportion of individuals in each age group.

- It represents the ratio of the various age classes in a population to each other at a given time.
- Based on the potential of individuals to reproduce, we classify individuals of a population into three groups: ***pre-reproductive, reproductive and post-reproductive***.
- Under a normal condition, the age structure of most populations has a pyramid shape, which is broader at the base and narrower at the tip
- If the proportion of the post reproductive age group is higher than the other groups, for example, this population is **declining**
- However, if it is highly broader at the base, the population has a great momentum **to grow fast**, as more young individuals enter the reproductive age group.

Diagram showing the age structure of a growing (left hand side) and stable (Middle) and dying (right hand side) populations

Age Determination in Animals

- There are different ways to determine the age of individuals of animal populations.
- The common ways include the following:
  - The wear and replacement of teeth in ungulates;
  - The growth rings in the cementum of teeth of carnivores and ungulates;
  - The annual growth rings in the horns of artiodactyls;
  - The weight of eye lens in rabbits which increase with age;
  - Plumage changes and wears in birds, etc.

Age Determination in Plants

- There are different ways of determining the age of a plant. The common ways include the following:
  - *Diameter at breadth height (dbb) - It is estimation based on the assumption that stem diameter* of plants increase with age. The greater the diameter the older the tree. It applied to the higher trees.
  - *Counting annual growth rings – The number of rings is used to determine the number o f* dormant seasons, hence the age. However, this is applicable only for temperate trees.

Population dynamics

- Population dynamics deals with the way populations are affected by birth rates, death rates and migration.
- studies short-term and long-term changes in the size and age composition of populations, and the biological and environmental processes influencing those changes.
- **Types of growth models**: A population growth is determined largely by the difference between **natality and mortality.**
- Depending on the direction of movement, migration could also affect the population density of a given locality.
- **There are two kinds of population growth models:**

  a) Exponential growth Model and

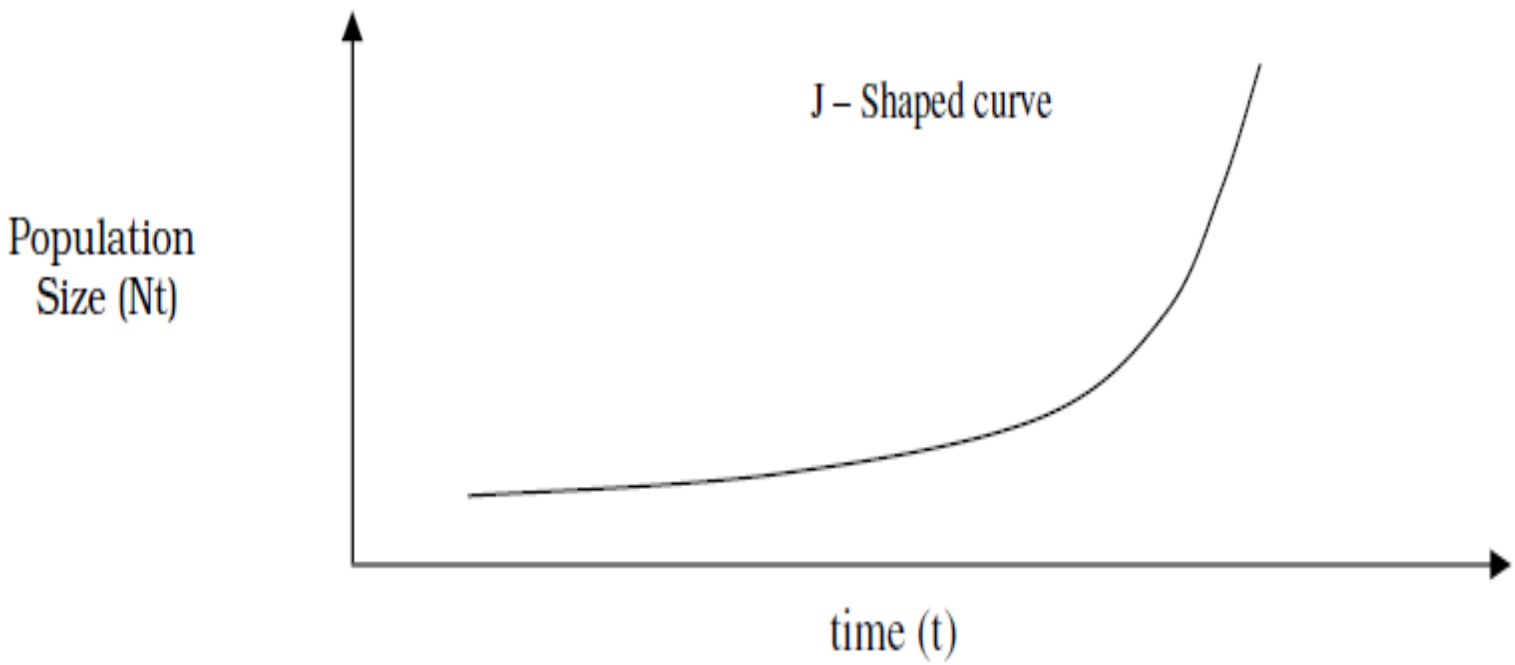
  b) Logistic growth Model

Exponential growth Model

- This model assumes that if there is **no environmental constraint** that hinders a population growth, the population shows geometric or exponential increase until it overshoots the ability of the environment to support it.
- The growth curve is ***J-shaped***
- This kind of population growth is common in new habitats where there is no shortage of resources.
- In this kind of growth model, there is exponential relationship between time “t” and the population number at time “t”.
- This is characteristic of r-selected species adapted to new (unstable) and resource-rich environment.

Exponential growth Model

Number of Generations /time- (t)	0	1	2	3	4	5	6	7	8	9	10
Total population size (N_t)	2	4	8	16	32	64	128	256	1012	2024	4048
Relationship between N_t and "t"	$2(2^0)$	$2(2^1)$	$2(2^2)$	$2(2^3)$	$2(2^4)$	$2(2^5)$	$2(2^6)$	$2(2^7)$	$2(2^8)$	$2(2^9)$	$2(2^{10})$



The pattern of population growth according to the exponential growth model

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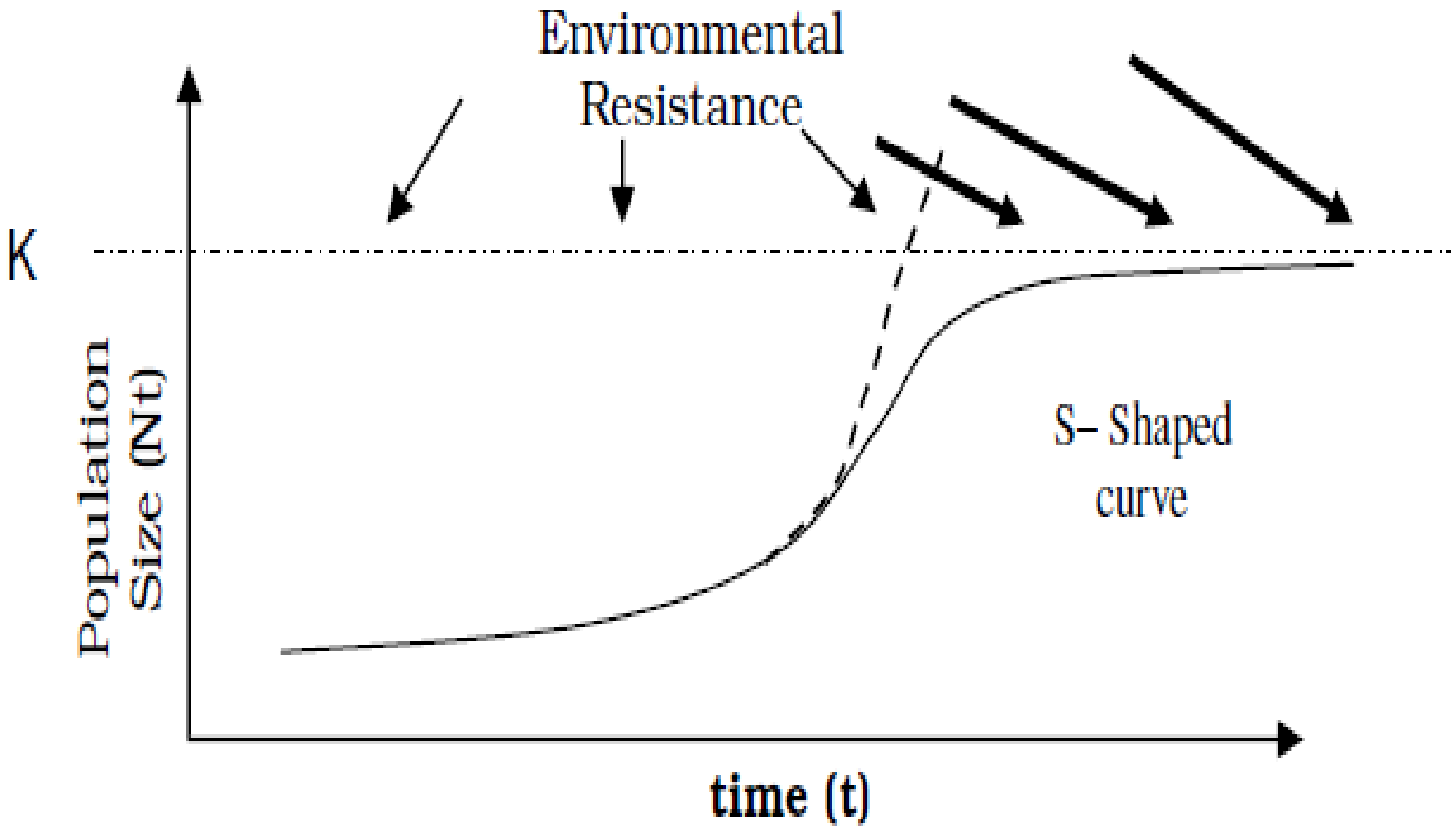
- The relationship between the population and the number of generations (or time) could be summarized by the following formula:
- **Nt =** N_0 **(2^t),** where Nt is the total number of population after time "t", N_0 is the starting population at time 0, and "t" is the number of generation (time of reproduction)
- If we consider all the natural processes i.e. the Birth rate (N) the Death rate (M), and net migration (Immigration (I) – Emigration (E)), the intrinsic population increase (r) is given by: **r = (N-M) + (I – E) or (N+I) - (M+E)**
- The overall population increase using exponential model is, therefore, given by the following equation:
- **Nt =** $N_0 e^{rt}$

where "e" is the base for natural logarithm given by a constant 2.71828; "r" is the intrinsic population increase, and "t" is time or number of generations

Logistic growth Model

- This growth model assumes that most populations cannot continue to grow exponentially because of the resistance coming from their environment that prevents from further growth
- As the result, the population grows exponentially until it reaches the carrying capacity (K).
- ***Carrying capacity*** is the maximum number of individuals that a habitat could support.
- However, as the population approaches to the carrying capacity, the growth is limited by the resistant factor hence the population increases **arithmetically.**
- This kind of growth is the characteristic of k-selected species adapted to stable environment, where there is competition for resources.

Logistic growth Model



The pattern of population growth according to the logistic growth model

Logistic growth Model

- When N is higher and closer to the carrying capacity (K), the value approaches to 0; there is no available resource in the habitat to accommodate a single individual.
- This shows that at any ecosystem the population growth is limited by the degree of the **environmental resistance**. The integrated equation of logistic growth is, therefore, given by:

$$N_t = \frac{K}{1 + \left[\frac{(K - N_0)}{N_0} \right] * e^{-rt}}$$

r and K selected Species

- In ***K*-selection**, organisms live and reproduce around *K*, and are sensitive to population density.
- In ***r*-selection**, organisms exhibit high rates of reproduction and occur in variable environments in which population densities fluctuate well below *K*.
  - **K-Selected Species**
- Poor colonizers
- Slow maturity
- Long-lived
- Low reproductive rate
- High investment in care for the young
- Specialist
- Good competitors

r-Selected Species

- Good colonizers
- Reach sexual maturity rapidly
- Short-lived
- High reproductive rate
- Low investment in care for the young
- Generalists
- Poor competitors

Population regulation

- Populations are often regulated by environmental factors.
- Population increase depends on:
  - The reproductive fitness and
  - Lifespan of individual members.
- Factors such as nutrient availability, flood, drought, predators and disease affect the population size.
- These environmental factors are classified into three categories depending on the degree of their variability in time, and the degree of predictability of the variation.

A) Constantly limiting factors

- This includes those factors that are always in short supply and are relatively constant.
- These factors have fairly constant magnitude, as a result of which individuals of a population have to compete for those scares resources.
- These kinds of factors therefore, always limit the size of the population.
- Examples include light, moisture and space for plants; and nesting site and food for birds.
- These kinds of factors do not usually produce large changes in a population.

B) Variably limiting factors

- These factors are variable but predictable.
- They includes seasonal drought or cold, or variation in food availability.
- These factors influence the population only at a certain times of the year or a certain period, and cause the population to crash.
- Some organisms have developed a way of escaping this problem.
- Migration of some birds and mammals, and dropping of leaves in deciduous trees in winter time are some of the examples.

C) Unpredictable factors

- They includes those factors that do not have regularity and predictability.
- Hence it changes the population considerably over time.
- Weather effects, grazing or predation pressure, disease, fire, and volcanic eruption are some of the examples.
- These factors may kill most of the population, all of a sudden.

Population Interaction

Types of Species Interactions

- Individuals of a population interact with each other and also with individuals of another population.
- There are two ways of population interactions:
  - ***Intraspecific interaction*** and
  - ***Interspecific interaction.***

Intra-specific Interactions

- These are kinds of interactions established between individuals of the same species forming a population.
- ***These include relations like***
  - Co-operation
  - Competition
  - Division of the territory and
  - Sometimes organization in hierarchical societies such as in social insects.
- Even if it is uncommon in most of the natural populations, cannibalism could be also considered as an example of intraspecific feeding relationship.

Interspecific Interactions

- This is interactions between different populations of different species.
- The major kinds of interaction could be explained in terms of feeding relationship.
- The major kinds of interactions are summarized in the following tables.

s/n	Type of interaction	desig nated	Benefited partner	Description	Example
1	Neutralism	(0, 0)	None	No harm no benefit	
2	Mutualism	(+, +)			
	Proto-cooperation		Both	Positive cooperation	Rhizobia and legumes; People and pets
	Symbiosis		Both	Positive obligatory	algae and fungi in Lichens
3	Commensalisms	(+ , 0)	Weaker	One sided benefit	Cattle and cattle egrets; epiphytes and trees
4	Amensalism	(- , 0)	Stronger	One sided harm	Penicilium and bacteria; allelopathy in eucalyptus
5	Parasitism	(- , +)	Weaker	One sided harm	Tape worms and human; Ticks and cattle
6	Predation	(- , +)	Stronger	One sided benefit	
	– carnivory		Stronger		Lion and buffalo
	– herbivory)		Stronger		Livestock and grasses
7	Competition	(- , -)	None	Harming both	Crops and weeds

Gain-loss matrix of species inter relationships

	Effect on weak species			
Effect on strong species		-	0	+
	-	Competition	Amensalism	Parasitism
	0	Amensalism	Neutralism	Commensalism
	+	Predation	Commensalism	Mutualism

Modes of Species Feeding Interactions

- The interactions are mostly the results of ecological adaptations.
- **Symbiosis** ("living together") is a phenomenon in which two organisms which are phylogenetically unrelated co-exist over a prolonged period of time, usually the lifetime of one of the individuals

1. **Mutualism** is an interaction between two or more species where both species derive benefits.

- can be lifelong interactions involving close physical and biochemical contact such as those between ***plants and mycorrhizal fungi***.
- can also be briefer, ***non-symbiotic interactions***, such as those between flowering plants and pollinators.
- Mutualisms may also be *obligatory or non-obligatory (facultative)*

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2. **Commensalisms**: is an interaction between two living organisms, where one organism benefits and the other is neither benefited nor harmed.

- The different forms of commensalism include the following:
- ***Phoresy***: *Using a second organism for transportation. Examples are the remora on a shark, or* mites on dung bugs.
- Both temporary and permanent phoresy exist.
- ***Inquilinism:*** *Using a second organism for housing. Examples are epiphytic plants (such as* many orchids) which grow on trees, or birds that live in holes in trees.
- ***Metabiosis:*** *A more indirect dependency, in which the second organism uses something created by the first organism*, however after the death of the first. An example is the hermit crabs that use gastropod shells to protect their bodies.

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3. **Amensalism** is a biological interaction, a type of symbiosis, between two species in which one **impedes or restricts** the success of the other without being affected positively or negatively, by the presence of the other

Antibiosis or allelopathy also explain similar interactions. E.g. Antibiotic interaction between Penicillium and Bacteria

- Allelopathy denotes the production of specific biomolecules by one plant that can induce suffering into another plant

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4. Predation

- **A** predator is an animal or other organism that hunts and kills other organisms, called prey, for food in an act called predation.
- Predators are either *carnivores or omnivores*

5. **Parasitism** is one version of symbiosis through which one species (the parasite) is benefited from the association by harming the other (the host)

6. Competition

- Individuals within a species, compete to gain the resources. As a result, several species less suited to compete for the resources may either adapt or die out
- According to evolutionary theory this competition within and between species for resources plays a critical role in natural selection
- ***Types of competition***
  - ***Interference competition*** is the interference of one species on the other by denying access to the resource
  - ***Exploitive competition:*** kind of competition demands **over exploitation of the limited resource** by one of the competent organism to reduce its availability for the other

    E .g. A number of exotic plants are aggressive in exploiting environmental resources that may cause resource depletion.

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7. **Cannibalism** is *intraspecific predation* between members of a population.

- Cannibalism is the act or practice of eating members of one's own species and usually refers to humans eating other humans.
- Some times animals prey member of their own kin mainly in stressed conditions, particularly those facing starvation. Two types of cannibalism is known

  a) ***Sexual cannibalism****: In this form of cannibalism, the female sometimes eats the male after* mating.

  This has been recorded in the female red-back spider, black widow spider, praying mantis, and scorpion, among others

  a) ***Size structured cannibalism****: This is a more common form of cannibalism in which large* individuals consume smaller conspecifics.

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8. Neutralism

- Neutralism describes the relationship between two species which do not interact with or affect each other
- It is used in ecology to describe biological interactions when the population density of one species has absolutely no effect whatsoever on the other
- Neutralism is **extremely unlikely and impossible** to prove

Evolution of Prey- Predator Adaptations in Animals

Adaptation of Predators *(Preying Strategies)*

- *sit-and-waiting (ambush hunting) – spend more time but less energy*
- *Trapping*
- *Chasing (saltatory) – exploit much energy but spend less time*

Anti-Predator Adaptation by Prey

- Physical armours, Running
- Mobbing: to surround and harass a potential predator in group
- Chemical attack as in the case of wasps, snakes and dart frog

- Camouflage or protective coloration as in the case of stick mantis
- Warning signals
- Aposematism/ Cryptic coloration
- Trickery: false features that resemble like enormous eyes or appendages
- Mimicking: imitating other dangerous animals
- hiding

Leaf moth camouflaged to dead leaves

An insect camouflaged to green leaf

Trickery made by a butterfly, it looks with many eyes

Mimicry

- Mimicry is one of several anti-predatory devices found in nature.
- Specifically it is a situation in which one species called the *mimic resembles in color, form, and/or behavior another species* called the *model*. *Three types of mimicry*

a) **Batesian mimics**: the mimic resembles the successful species but does not share the attribute that discourages predation. Ash Borer Moth vs Wasp

b) **Müllerian mimics**: the mimic resembles the successful species and shares the anti-predation attribute (dangerous or unpalatable ones). This is usually done by unpalatable animals to avoid testing by predators. Wasp vs bee

c) **Aggressive mimics**: “a wolf with sheep’s clothing” e.g. parasitoid wasps exactly resemble honeybees

Coevolution of Herbivore-Plant Adaptation

A. Mechanisms of Plant Defence Against Herbivory

- Mechanical /Morphological Defences - external structural defences that discourage herbivory
- Associational Defences (biotic defence): features that indirectly protect the plant by enhancing the probability of attracting natural enemies

Acacia tree with many thousands of insect houses (domatia) for the purpose of associational defence.

•Ant species obtains its food exclusively from the food bodies produced by the plant

•Stem walls to create housing (domatia) for an ant species - who in turn protects its plant against herbivores.

Chemical Defenses

- Produce secondary metabolites (allelochemicals). play a defensive role in interspecific communication which are used by a higher trophic level for the discovery of food.
- When a plant is attacked, it releases allelochemics that are different from its ratio of volatiles normally produced.
- Predators use these volatiles as food signal, attracting them to the damaged plant and leading them to the feeding herbivores.

Herbivore Adaptations against Plant Defense

- Physical Adaptations – structure of teeth
- Microbial Symbionts – cellulose digestion
- Biochemical Adaptations - enzymes
- Physiological Adaptation (herbivore reuse of plant chemicals)
- Behavioral Adaptations – selective eating
- Host Manipulation

End of chapter two